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TABLE OF MONOMIAL SYMMETRIC FUNCTIONS OF WEIGHT 9

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Communicated by Sir Shah Sulaiman

(Received on February 10, 1941)

Introduction

Considering the important part that is played by monomial symmetric functions in the mathematical theory of statistics, O'Toole[1] and Sukhatme[2] have constructed tables of these functions for weight up to 8. Recently M. Zia-ud-Din[3] has published the table for weight 9. I had occasion to use the last table, and the results led me to suspect the accuracy of its figures. On checking it, I detected errors in 26 distinct places. In the following pages, I have reconstructed the table, removing all the errors and arranging the various functions in dictionary order. Different methods have been used before for constructing the tables. The method followed in constructing the present table, involved the calculation of symmetric functions of order up to 9, and these were checked by the already existing tables of weight up to 8. Each figure has been calculated out at least twice before being tabulated, and it is believed that the table is free from any error of calculation.

Directions for Reference to the Table.—The partitions of 9 are arranged in dictionary order in the extreme left-hand column. The extreme top row gives the power-sum functions of degree 9. For example, $1^3 24$ denotes $S_1{}^3 S_2 S_4$. To find the coefficient of any power-sum function in the expansion of a given partition, we find the intersection of the column and row under consideration. The number there found, divided by D tabulated in the extreme right-hand column, will give the required coefficient.

TABLE OF WEIGHT 9

Sr's→	$1^2 34$	234	14^2	$1^4 5$	$1^2 25$	$2^2 5$	135	45	$1^3 6$	126	36	$1^2 7$	27	18	9	D
(9)															1	1
(81)														1	−1	1
(72)													1		−1	1
(71^2)												1	−1	−2	2	2
(63)											1				−1	1
(621)										1	−1		−1	−1	2	1
(61^3)									1	−3	2	−3	3	6	−6	6
(54)								1							−1	1
(531)							1	−1			−1			−1	2	1
(52^2)						1		−1					−2		2	2
(521^2)					1	−1	−2	2		−2	2	−1	3	4	−6	2
(51^4)				1	−6	3	8	−6	−4	12	−8	12	−12	−24	24	24
$(4^2 1)$			1					−2						−1	2	2
(432)		1						−1			−1		−1		2	1
(431^2)	1	−1	−2				−2	4			2	−1	1	4	−6	2

In dictionary order of monomial symmetric functions from (9) to (431^2). D=the common denominator.

TABLE OF WEIGHT 9

Sr's→	1^9	1^72	1^52^2	1^32^3	12^4	1^63	1^423	1^22^23	2^33	1^33^2	123^2	3^3	1^54	1^324	12^24	D
(42^21)															1	2
(421^3)														1	−3	6
(41^5)													1	−10	15	120
(3^3)												1				6
(3^221)											1	−1				2
(3^21^3)										1	−3	2				12
(32^3)									1							6
(32^21^2)								1	−1		−4	2			−2	4
(321^4)							1	−6	3	−4	20	−8		−4	12	24
(31^6)						1	−15	45	−15	40	−120	40	−6	60	−90	720
(2^41)					1				−4						−6	24
(2^31^3)				1	−3			−9	11		18	−6		−3	27	36
(2^21^5)			1	−10	15		−10	80	−50	20	−140	40	−1	50	−165	240
(21^7)		1	−21	105	−105	−7	175	−735	315	−280	1120	−280	42	−630	1260	5040
(1^9)	1	−36	378	−1260	945	168	−2520	7560	−2520	3360	−10080	2240	−756	7560	−11340	362880

In dictionary order from (42^21) to (1^9). D=the common denominator.

(*Continued on the next page.*)

TABLE OF

S_r's→	$1^2 34$	234	14^2	145	$1^2 25$	25^2	135	45
$(42^2 1)$		−2	−1			−1		3
(421^3)	−3	5	6		−3	3	6	−12
(41^5)	20	−20	−30	−5	30	−15	−40	54
(3^3)								
$(3^2 21)$		−2					−2	2
$(3^2 1^3)$	−6	6	6				12	−12
(32^3)		−3				−3		3
$(32^2 1^2)$	−1	9	2		−2	4	8	−10
(321^4)	24	−38	−24	−1	18	−15	−56	54
(31^6)	−210	210	180	30	−180	90	384	−324
$(2^4 1)$		12	3			12		−12
$(2^3 1^3)$	9	−51	−18		18	−36	−36	54
$(2^2 1^5)$	−140	280	150	10	−180	174	320	−324
(21^7)	1470	−1890	−1260	−210	1764	−1134	−2688	2268
(1^9)	−15120	15120	11340	3024	−18144	9072	24192	−18144

(*Continued from the preceding page.*)

WEIGHT 9

1^36	126	36	1^27	27	18	9	D
	−2	2		4	2	−6	2
−1	9	−8	6	−12	−18	24	6
20	−60	40	−60	60	120	−120	120
		−3				2	6
	−1	5		2	2	−6	2
−1	3	−14	6	−6	−18	24	12
		2		6		−6	6
	8	−14	2	−14	−12	24	4
8	−48	64	−36	60	96	−120	24
−120	360	−360	360	−360	−720	720	720
	8	−8		−24	−6	24	24
2	−60	58	−18	90	72	−120	36
−60	420	−360	240	−480	−600	720	240
840	−3360	2520	−2520	3240	5040	−5040	5040
−10080	30240	−20160	25920	−25920	−45360	40320	362880

In dictionary order from (42^21) to (1^9). D = the common denominator.

References

1. O'Toole, *Annals of Math. Statistics*, (*U.S.A*) 2, 1931, pp. 101—149.
2. Sukhatme, P.V., *Philo. Tr. R.S.* (*A*) 760, Vol. 237, pp. 375—409.
3. Zia-ud-Din, M., *Proc. Nat. Acad. Sci., India*, Vol. 10, part 2, pp. 53—60, 1940.

THE TABLE OF SYMMETRIC FUNCTIONS OF WEIGHT 10

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This paper is a supplement to the paper by S. M. Kerawala (supra) which it follows. The method of calculation has been essentially the same as described in that paper.

It may be mentioned that M. Zia-ud-Din [1] has also been working on the same table, but the method used by him is the one developed by O'Toole [2]. This method requires a knowledge of the table of 9 before the table for 10 can be constructed. As the table of 9 published by M. Zia-ud-Din [3] contains numerous errors, his table of 10 must contain many more errors. The table given here has been thoroughly checked, and it is believed that it contains no error of computation.

TABLE OF WEIGHT 10

S_r's→	1^{45}	5^2	1^46	1^226	2^26	136	46	1^37	127	37	1^28	28	19	10	D
(10)														1	1
(91)													1	−1	1
(82)												1		−1	1
(81^2)											1	−1	−2	2	2
(73)										1				−1	1
(721)									1	−1		−1	−1	2	1
(71^3)								1	−3	2	−3	3	6	−6	6
(64)							1							−1	1
(631)						1	−1			−1			−1	2	1
(62^2)					1		−1					−2		2	2
(621^2)				1	−1	−2	2		−2	2	−1	3	4	−6	2
(61^4)			1	−6	3	8	−6	−4	12	−8	12	−12	−24	24	24
(5^2)		1												−1	2
(541)	1	−1					−1						−1	2	1

In dictionary order from (10) to (541). D=the common denominator.

TABLE OF WEIGHT 10

S_r's→	$1^6 4$	$1^4 24$	$1^2 2^2 4$	$2^3 4$	$1^3 34$	1234	$3^2 4$	$1^2 4^2$	24^2	$1^5 5$	$1^3 25$	$12^2 5$	$1^2 35$	235	D
(532)														1	1
(531^2)													1	−1	2
$(52^2 1)$												1		−2	2
(521^3)											1	−3	−3	5	6
(51^5)										1	−10	15	20	−20	120
$(4^2 2)$									1						2
$(4^2 1^2)$								1	−1						4
(43^2)							1								2
(4321)						1	−1		−1					−1	1
(431^3)					1	−3	2	−3	3				−3	3	6
(42^3)				1					−3						6
$(42^2 1^2)$			1	−1		−4	2	−1	5			−2		4	4
(421^4)		1	−6	3	−4	20	−8	12	−18		−4	12	12	−20	24
(41^6)	1	−15	45	−15	40	−120	40	−90	90	−6	60	−90	−120	120	720

(*Continued on the next page.*)

In dictionary order from (532) to (41^6). D = common denominator.

Table of Weight 10

Sr's→	1^5	5^2	1^6	$1^2 2^6$	2^6	$1^3 6$	46	$1^3 7$	127	37	$1^2 8$	28	19	10	D
(532)		−1								−1		−1		2	1
(531^2)	−2	2				−2	2			2	−1	1	4	−6	2
(52^21)	−1	2			−1		1		−2	2		4	2	−6	2
(521^3)	6	−6		−3	3	6	−6	−1	9	−8	6	−12	−18	24	6
(51^5)	−30	24	−5	30	−15	−40	30	20	−60	40	−60	60	120	−120	120
(4^22)							−2					−1		2	2
(4^21^2)	−4	2					4				−1	1	4	−6	4
(43^2)							−1			−2				2	2
(4321)	−1	1				−1	3		−1	3		2	2	−6	1
(431^3)	12	−6				6	−12	−1	3	−8	6	−6	−18	24	6
(42^3)					−3		5					6		−6	6
(42^21^2)	6	−4		−2	4	4	−12		8	−8	2	−14	−12	24	4
(421^4)	−48	24	−1	18	−15	−32	54	8	−48	40	−36	60	96	−120	24
(41^6)	324	−144	30	−180	90	240	−300	−120	360	−240	360	−360	−720	720	720

(*Continued from the preceding page.*) In dictionary order from (532) to (41^6). D = the common denominator.

TABLE OF

Sr's→	$1^6 4$	$1^4 24$	$1^2 2^2 4$	$2^3 4$	$1^3 34$	1234	$3^2 4$
$(3^3 1)$							−3
$(3^2 2^2)$							−1
$(3^2 21^2)$						−4	6
$(3^2 1^4)$					−8	24	−22
$(32^3 1)$				−1		−3	3
$(32^2 1^3)$			−3	3	−1	27	−20
(321^5)		−5	30	−15	40	−190	110
(31^7)	−7	105	−315	105	−490	1470	−700
(2^5)				−10			
$(2^4 1^2)$			−6	14		24	−12
$(2^3 1^4)$		−3	54	−51	12	−204	96
$(2^2 1^6)$	−1	75	−495	285	−280	1680	−700
(21^8)	56	−1260	5040	−2100	3920	−15120	5600
(1^{10})	−1260	18900	−56700	18900	−50400	151200	−50400

In dictionary order from $(3^3 1)$ to (1^{10}).

TABLE OF

Sr's→	145	5^2	$1^4 6$	$1^2 26$	$2^2 6$	136	46
$(3^3 1)$						−3	3
$(3^2 2^2)$		2			−1		1
$(3^2 21^2)$	4	−4		−1	1	10	−10
$(3^2 1^4)$	−48	24	−1	6	−3	−56	54
$(32^3 1)$	3	−6			6	2	−8
$(32^2 1^3)$	−30	24		12	−18	−42	48
(321^5)	270	−144	10	−120	90	320	−300
(31^7)	−2268	1008	−210	1260	−630	−2520	2100
(2^5)					20		−20
$(2^4 1^2)$	−24	24		8	−44	−16	52
$(2^3 1^4)$	216	−144	2	−120	186	232	−300
$(2^2 1^6)$	−1944	1008	−90	1260	−1110	−2160	2100
(21^8)	18144	−8064	1680	−13440	8400	20160	−16800
(1^{10})	−181440	72576	−25200	151200	−75600	−201600	51200

In dictionary order from $(3^3 1)$ to (1^{10}).

WEIGHT 10

$1^2 4^2$	24^2	$1^5 5$	$1^3 25$	$12^2 5$	$1^2 35$	235	D
							6
						−4	4
	2				−2	6	4
12	−12				24	−24	48
	3			−3		12	6
3	−15		−2	12	12	−40	12
−60	90	−1	30	−75	−140	204	120
630	−630	42	−420	630	1344	−1344	5040
	15						120
3	−27			24		−48	48
−36	126		24	−144	−72	264	144
360	−810	12	−360	1044	960	−1728	1440
−5040	6300	−336	4704	−9072	−10752	13440	40320
56700	−56700	6048	−60480	90720	120960	−20960	3628800

D = the common denominator. (*Continued from p. 62, continued below*)

WEIGHT 10.

$1^3 7$	127	37	$1^2 8$	28	19	10	D
		6			2	−6	6
		4		4		−6	4
	4	−16	2	−8	−12	24	4
8	−24	64	−36	36	96	−120	48
	6	−12		−18	−6	24	6
2	−42	64	−18	66	72	−120	12
−60	300	−360	240	−360	−600	720	120
840	−2520	2400	−2520	2520	5040	−5040	5040
				−30		24	120
	−48	48	−6	102	48	−120	48
−24	360	−336	144	−504	−480	720	144
480	−2880	2400	−1800	3240	4320	−5040	1440
−6720	25920	−19200	20160	−25200	−40320	40320	40320
86400	−259200	72800	−226800	226800	403200	−362880	3628800

D = the common denominator. (*Continued from above*)

TABLE OF WEIGHT 10

Sr's→	1^{10}	$1^8 2$	$1^6 2^2$	$1^4 2^3$	$1^2 2^4$	2^5	$1^7 3$	$1^5 23$	$1^3 2^2 3$	$1^2 3^3$	$1^4 3^2$	$1^2 23^2$	$2^2 3^2$	13^3	D
$(3^3 1)$														1	6
$(3^2 2^2)$													1		4
$(3^2 21^2)$												1	−1	−2	4
$(3^2 1^4)$											1	−6	3	8	48
$(32^3 1)$										1			−3		6
$(32^2 1^3)$									1	−3		−6	8	6	12
(321^5)								1	−10	15	−5	50	−35	−40	120
(31^7)							1	−21	105	−105	70	−420	210	280	5040
(2^5)						1									120
$(2^4 1^2)$					1	−1				−8			12		48
$(2^3 1^4)$				1	−6	3			−12	44		36	−60	−24	144
$(2^2 1^6)$			1	−15	135	−15		−12	160	−300	30	−420	370	240	1440
(21^8)		1	−28	210	−420	105	−8	280	−1960	2520	−560	4480	−2800	−2240	40320
(1^{10})	1	−45	630	−3150	4725	−945	240	−5040	25200	−25200	8400	−50400	25200	22400	3628800

In dictionary order from $(3^3 1)$ to (1^{10}) D=the common denominator.

(*Continued on pp 60–61*)

References

1. M. Zia-ud-Din, Abstract, ***Indian Science Congress.*** 1941, Section of Mathematics and Statistics, paper 20.

2. O'Toole: ***Annals of Math and Statistics,*** (*U. S. A.*) 2 (1931), pp. 101—149.

3. M. Zia-ud-Din, ***Proc. Nat. Acad. Sci.***, India, Vol. 10, II, pp. 53–60, 1940.

SOME PROPERTIES OF RECTILINEAR CONGRUENCES

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1. Consider a line of the Congruence which meets the surface of reference at(x, y, z) and whose direction cosines are X, Y, Z. The co-ordinates of a point P on it at a distance t from x, y, z are given by $\xi = x + tX$, $\eta = y + tY$, $\zeta = z + tZ$. Then the locus of P is another surface. Take a small element of area dS at P bounded by a closed curve C. Let θ be the angle which the line (X, Y, Z) makes with the normal to dS, then $\cos\theta = \dfrac{\Sigma X(\eta_1\zeta_2 - \eta_2\zeta_1)}{V}$ where $V = \sqrt{(\Sigma\xi_1^2)(\Sigma\xi_2^2) - (\Sigma\xi_1\xi_2)^2}$

$$\therefore \quad dS\cos\theta = \frac{\Sigma X(\eta_1\zeta_2 - \eta_2\zeta_1)}{V} V\,dudv$$

$$\therefore \quad \frac{dS\cos\theta}{dudv} = \Sigma X(\eta_1\zeta_2 - \eta_2\zeta_1) = \Sigma X[(y_1 + tY_1)(z_2 + tZ_2) - (y_2 + tY_2)(z_1 + tZ_1)]$$

$$= t^2\Sigma X(Y_1Z_2 - Y_2Z_1) + t.\Sigma[X(y_1Z_2 + Y_1z_2 - y_2Z_1 - Y_2z_1)] + \Sigma X(y_1z_2 - y_2z_1) \ldots (1)$$

If $\Sigma X(Y_1Z_2 - Y_2Z_1) = 0$, then $\dfrac{dS\cos\theta}{dudv}$ is linear in t and hence one focus is at infinity.

Hence $\Sigma X(Y_1Z_2 - Y_2Z_1) = 0$ *is the necessary and sufficient condition that one focus of the Congruence be at infinity*

It is a necessary, but not a sufficient, condition that $\dfrac{dS\cos\theta}{dudv}$ = constant along the pencil du, dv. If $\dfrac{dS\cos\theta}{dudv}$ is constant along any thin pencil (*i.e.*, if the normal section of any thin pencil is constant along the pencil), the second focus must also be at infinity.

Again $\Sigma X(Y_1Z_2 - Y_2Z_1) = 0$ or $\begin{vmatrix} X & Y & Z \\ X_1 & Y_1 & Z_1 \\ X_2 & Y_2 & Z_2 \end{vmatrix} = 0$

gives on squaring

$$\begin{vmatrix} 1 & 0 & 0 \\ 0 & \Sigma X_1^2 & \Sigma X_1X_2 \\ 0 & \Sigma X_1X_2 & \Sigma X_2^2 \end{vmatrix} = 0, \text{ or } \Sigma X_1^2 . \Sigma X_2^2 - (\Sigma X_1X_2)^2 = 0,$$

or $\Sigma(Y_1Z_2 - Y_2Z_1)^2 = 0 \quad \therefore \quad Y_1Z_2 - Y_2Z_1 = 0,\ Z_1X_2 - Z_2X_1 = 0,$

$X_1Y_2 - X_2Y_1 = 0$, assuming the Congruence to be real,

or $\frac{J(Y,Z)}{J(u,v)} = 0, \frac{J(Z,X)}{J(u,v)} = 0, \frac{J(X,Y)}{J(u,v)} = 0.$

$\therefore$ X, Y, Z are functions of one parameter only[1], *i.e.*, the rays of the congruence are parallel to the generators of some cone, ∞^1 rays being in general parallel to each generator, or one sheet of the focal surface is a curve in the plane at infinity.

Hence the Congruence which consists of a system of lines parallel to a fixed direction has one focus always at infinity.

In other words, 'the necessary and sufficient condition that all rays of a congruence have one focus at infinity is that they all intersect a curve lying at infinity.'

Note.—In the particular case of a normal congruence, the rays are normals to some surface, and the focal distances from the surface are the two principal radii of curvature.

So, if one focus is at infinity, $LN - M^2 = 0$, where L,M,N are fundamental magnitudes of the second order, or the surface is a developable surface. The normals of a developable surface have the property in question, and therefore the problem in this case becomes trivial.

2. Consider the Congruence formed by parallels to the tangents of a twisted curve C in the osculating planes. Form the equation for the values of t, giving the focal points. Any point P on the ray (u,v) is $[x(u) + vl_2(u) + tl_1(u), \ldots, \ldots,]$ where x, y, z are the co-ordinates of a point on C, u is the arc of C, and l_1,m_1,n_1; l_2,m_2,n_2 are the direction cosines of the tangent and the principal normal to the curve C at the point (x,y,z).

The point P describes a curve tangent to the ray

if $d[x + vl_2 + tl_1] \propto l_1, \ \ldots, \ \ldots,$

or $l_1du + v\left(\frac{-l_1}{\rho} + \frac{l_3}{\sigma}\right)du + l_2dv + t.\frac{l_2}{\rho}du = l_1d\theta$, say,

or $\left[l_1\left(1 - \frac{v}{\rho}\right) + \frac{vl_3}{\sigma} + t\frac{l_2}{\rho}\right]du + l_2dv - l_1d\theta = 0,$

and two similar equations.

Eliminating $du, dv, d\theta$ we get

$$\begin{vmatrix} l_1\left(1 - \frac{v}{\rho}\right) + \frac{vl_3}{\sigma} + t.\frac{l_2}{\rho} & l_2 & l_1 \\ m_1\left(1 - \frac{v}{\rho} + \frac{vm_3}{\sigma} + t.\frac{m_2}{\rho}\right. & m_2 & m_1 \\ n_1\left(1 - \frac{v}{\rho}\right) + \frac{vn_3}{\sigma} + t.\frac{n_2}{\rho} & n_2 & n_1 \end{vmatrix} = 0,$$

or $\Sigma l_3\left[l_1\left(1 - \frac{v}{\rho}\right) + \frac{vl_3}{\sigma} + t.\frac{l_2}{\rho}\right] = 0$, or $\frac{v}{\sigma} = 0.$

The quadratic in t has reduced to constant $= 0$, so that both of its roots are infinite.

Hence the Congruence formed by parallels to the tangents of a twisted curve C in the osculating planes has in general two foci always at infinity.

Reference

1. Cf. Cisotti, Sopra le congruenze rettilinee solenoidali, *Rendiconti dei Lincei*, 1910.

ISONITROSO-MALONYL-GUANIDINE, A CORRECTION

By Sikhibhushan Dutt

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(Received on January 25, 1941)

SUMMARY

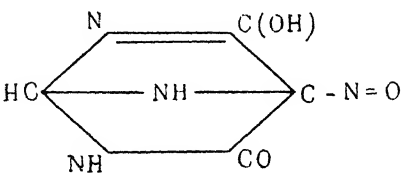
Contrary to a previous report, it has now been found that isonitroso-malonyl-guanidine does not form stable salt with organic bases. The previously prepared salts have now been found on close examination to be mixtures.

Isonitroso-malonyl-guanidine was first prepared by Traube[2] in 1893, but the product obtained by him was very impure and amorphous, and the calcium and barium salts of the substance prepared by him had analytical data very far from the theoretical. In 1939, isonitroso-malonyl-guanidine was obtained by Dass and Dutt,[1] who prepared the substance by a new method and succeeded in obtaining it in a perfectly pure and crystalline condition. They also prepared a number of organic and inorganic salts of the substance, and from the observation of their chemical behaviour and absorption spectra, they derived far-reaching generalisations on colour in relation to the chemical constitutions of the substance.

After the publication of the above-mentioned work, the present author casually happened to examine the properties of the interesting substance more closely, and was surprised to find that its acidic character was very feeble, indeed so much so, that although in solution there is undoubtedly a certain amount of salt formation on treatment with bases as is evidenced by the change of colour from pink to light violet in many cases, yet the salts on isolation and purification are found to be practically completely dissociated into the original mother substance, and have the same properties and analytical data. The salts as isolated by the method of Dass and Dutt have been found by close examination by the present author to be very impure consisting of admixtures of the mother compound in large proportions together with smaller quantities of the salts in varying stages of decomposition. All the salts have been found to have the same decomposition point on purification as the mother substance, namely, 180°—195°C. and have practical identical absorption maxima as the parent material (about 5800 Å) as has been recorded in the original paper mentioned above.

Under such circumstances the conclusion is inevitable that the organic salts of isonitroso-malonyl-guanidine obtained by Dass and Dutt were impure substances

which dissociate completely into the parent compound on careful and exhaustive purification, due to the exceedingly feeble acidic character of the latter owing to the following constitution which it undoubtedly possesses :



Isonitroso-malonyl-guanidine.

References

1. Dass and Dutt, *Proc. Nat. Acad. Sci. Ind.*, 1939, IX, 93.
2. Traube, Ber., 1893, 20, 2555.

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SECTION A

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CHEMICAL EXAMINATION OF THE SEEDS OF *SOLANUM INDICUM* LINN. PART I—EXAMINATION OF THE FATTY OIL

By Brijmohan Saran

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Communicated by Dr. B. K. Singh

(Received on August 18, 1941.)

SUMMARY

The fatty oil from the seeds of *Solanum indicum* Linn, has been examined. The fatty acids from the oil are found to contain :—

	Oleic acid	36·33%
	Linolic acid	52·37%
	Stearic acid	9·04%
and	Lignoceric acid	2·26%

Oleic acid is not the chief constituent in liquid acids and the myristic acid is not present at all, whereas Dymock[1,2] mentions its presence.

Solanum indicum Linn. commonly known as *Birhatta* in Hindi and *Vrihati* in Sanskrit belongs to the natural order Solanaceæ. It is a common undershrub found throughout tropical India upto the height of about 5000 ft. The fruit of the plant is globose and yellow when ripe. The plant is of importance in Hindu medicine[1] as the source of one of the drugs required for the preparation of *Dasamula Kvatha*. It is diuretic, useful in dropsy and is largely used for the cure of tooth-ache, when the vapour of the burning seeds relieves the pain[2]. It is also used in asthma, cough, scorpion sting and difficult parturition[3]. The juice of the leaves with fresh juice of ginger is administered to stop vomiting. The leaves and fruits rubbed up with sugar are used as an external application to itch. Indian doctors prescribe some preparation of its root in the case of dysuria and inchuria in the quantity of half a tea cup full twice daily[4].

Inspite of its great medicinal importance very little work has been done on the chemical examination of the plant. According to Dymock, Warden and Hooper[5], the seeds contain 13·5% of a yellow oil consisting of the glycerides of myristic and oleic acids and an alkaloid resembling Solanine. They also mention that the fruit when dried and kept for some time becomes almost tasteless, compared with its acridity and bitterness when fresh, and it would consequently appear that the alkaloid is

decomposed. Tauber and Kleiner[6] have found that the plant contains a tryptic enzyme and several carbohydrases, including a maltase, an invertase aud a melibiase.

Brodie[7] states that a fuller investigation of the oil from the seeds will be useful as the plant grows wild extensively and could be produced in commercial quantities, if found useful in industry especially as it has good drying properties. With this object in view, the examination of the oil of the seeds of *Solanum indicum* was undertaken and the results so far obtained are reported in this paper. Further work on the chemical examination of the seeds and other parts of this plant is in progress.

Experimental

Three Kilos of the authentic seeds obtained from the Punjab Ayurvedic Pharmacy, Amritsar, were crushed and extracted with benzene in a 5-litre flask in three instalments when about 425 gms. of a greenish brown oil was obtained. It was then purified with animal charcoal and Fuller's earth. The oil on keeping deposited a solid, the chemical examination of which is in progress. On examination, the oil was found to be a drying oil having the following chemical and physical constants :—

Table I

Yield of oil from seeds	14·5%
Sp. Gr. at 34°C/34°C	0·9159
Refractive index at 33°C	1·4652
Acid value	3·24
Saponification value	190·2
Acetyl value	Nil
Hehner value	94·1
Iodine value	136·25
Reichert-Meissl value	0·38
Unsaponifiable matter	0·09%

300 gms. of the oil were then saponified in the usual manner with alcoholic sodium hydroxide solution and the unsaponifiable matter extracted with ether in a big separating funnel. The soap solution was then decomposed when a mixture of fatty acids having the following constants was obtained :—

Table II

Consistancy	Liquid
Neutralisation value	195·4
Mean molecular weight	287·2
Iodine value	138·1

The mixture of fatty acids was then separated into solid and liquid acids by the Twitchell's Lead salt alcohol process[8]. The following table gives the percentage, neutralisation value, mean molecular weight and iodine value of the solid and the liquid acids.

TABLE III

Acids	Percentage in mixed acids	Neutralisation value	m.m.wt.	Iodine value
Solid	11·3	182·0	302·6	2·62
Liquid	88·7	199·5	281·1	145·2

EXAMINATION OF THE UNSATURATED ACIDS

Elaidin Test:—A positive test was obtained showing the presence of oleic acid.

Oxidation with Potassium permanganate:—10 gms. of the acids were dissolved in aqueous potassium hydroxide solution and oxidised by a dilute solution of Potassium permanganate[9] at room temperature with constant stirring and after the reaction was over a current of sulphur dioxide was passed to dissolve the precipitated manganese dioxide. The insoluble oxidation product was filtered; it was successively extracted with ether and boiling water, when dihydroxy stearic acid (m.pt. 131-132°C) and Tetra-hydroxy stearic acid (Sativic acid, m.pt. 164-165°C) were isolated showing thereby the presence of oleic and linolic acids. Hexahydroxy stearic acid (Linusic acid) was not produced showing the absence of linolenic acid.

The constituents of the unsaturated acids were determined quantitatively by the method of Eibner and Muggenthalor[10] and Jamieson and Boughman[11] as follows:—

To a known weight (11·5 gm.) of the mixture of the liquid acids dissolved in dry ether (250c.c.) and cooled to −10°C, the bromine was gradually added till it was in slight excess; the temperature was not allowed to rise above −5°C during the process. The mixture was then allowed to stand for two hours at −10°C. The hexabromide of linolenic acid is insoluble in ether and is precipitated. On standing no precipitate was obtained showing the complete absence of linolenic acid. The ethereal solution was treated with an aqueous solution of sodium thiosulphate in a separating funnel and the excess of bromine was thus removed. The ethereal solution was washed with water, dried over anhydrous sodium sulphate and ether removed by distillation. The residue was taken up with 750c c. of dry petroleum ether, boiled to bring it into solution and kept overnight in a frigidaire. On standing the tetrabromide of linolic acid was precipitated. It was filtered and washed with dry petroleum ether. The filtrate and washings were concentrated to about 50 cc. cooled and allowed to stand overnight in the frigidaire The second crop of the tetrabromide was added to the first and weighed. It was found to melt at 112·5°C (melting point of tetrabromide of linolic acid 113-114°C). Finally the petroleum ether filtrate was evaporated to dryness and weighed. The bromine content of this residue was determined

by Piria and Schiffs' method. From this the percentages of oleic dibromide and linolic tetrabromide as well as those of oleic and linolic acids were calculated (Table IV):—

TABLE IV

Weight of acids taken	11·8640 gms.
Weight of tetrabromide	8·7488 gms.
Melting point of the tetrabromide	112·5°C
Weight of linolic acid	4·083 gms.
Weight residue (di- and tetrabromide)	13·1539 gms.
Percentage of bromine in the residue	43·72
Weight of tetrabromide in the residue	5·782 gms.
Weight of dibromide in the residue	7·3719 gms.
Weight of linolic acid in the residue	2·699 gms.
Weight of oleic acid in the residue	4·704 gms.
Total weight of linolic acid	6·782 gms.
Percentage of oleic acid in liquid acids	40·96
Percentage of linolic acid in liquid acids	59·04
Percentage of oleic acid in mixed acids	36·33
Percentage ef linolic acid in mixed acids	52·37

EXAMINATION OF THE SOLID ACIDS

The solid acids (17 gms.) were converted into their methyl esters:—The acids were dissolved in absolute methyl alcohol (250 c.c.) and a current of dry hydrochloric acid gas was passed till the solution was saturated. The mixture was heated under reflux for five hours nnd methyl alcohol distilled off as far as possible. The esterified product was neutralised with sodium bicarbonate and distilled water added. The ester was taken up in ether, washed with water, dehydrated over anhydrous sodium sulphate and the solvent removed by distillation

The esters were subjected to fractional distillation under reduced pressure (8 m.m). The boiling ranges and weights of the different fractions were recorded. The saponification value, the iodine value and the mean molecular weight were determined for each fraction. The following table contains the results obtained:—

TABLE V

Fraction No.	Wt. in gms.	Boiling ranges at 8 m.m. pressure	Iodine value	Sap value	Mean Mol.wt.	Unsaturated esters %	Unsaturated esters gms.	Weight of Saturated ester in gms.
1.	8·7108	185—190°	2·26	189·9	295·4	1·63	0·143	8·5688
2.	2·2135	190—195°	2·49	188·1	298·4	1·79	·0396	2·1739
3.	1·3534	195—200°	5·04	146·7	382·4	3·64	·0493	1·3041
4.	1·4132	above 200°	5·88	146·1	384·0	4·23	·0598	1·3534
Residue (Decomposed)	1·3900	...	...	...	...	...	..	...

The molecular weights of fractions 1 and 2 and 3 and 4 are identical and show that they are the methyl esters of stearic and Lignoceric acids respectively. The acids from the above fractions were liberated and examined.

The acids from fractions 1 and 2 were crystallised from alcohol and acetone separately. They were found to melt at 57°C in both the cases. The authentic sample of stearic acid available in the laboratory melts at 58°C (melting point 69° in literature). The stearic acid from fraction 1 and 2 was mixed with authentic sample in various proportions and the mixtures were found to melt between 57 and 58°C in each case. Hence, fractions 1 and 2 contain methyl esters of stearic acid.

The acids from fractions 3 and 4 were crystallised from acetone and were found to melt at 63°C. A further crystallisation did not raise the melting point. As the authentic sample of lignoceric acid was not available, it was not possible to confirm the result by the determination of mixed melting point. The molecular weight indicates that the two fractions contain the methyl esters of lignoceric acid but no definite conclusion could be drawn for want of authentic samples.

On calculation the solid acids are found to contain

Stearic acid	80·01%
Lignoceric acid	19·99%

The percentage of these acids in mixed acids is as follows:—

Stearic acid	9·04%
Lignoceric acid	2·26%

Examination of Unsaponifiable Matter

The unsaponifiable matter obtained gives reactions for a phytosterol, sitosterol found in most vegetable oils, but the amount being too small it could not be fully investigated.

Acknowledgements

The author is highly indebted to the "Kanta Prasad Research Trust of the Allahabad University" for a scholarship which enabled him to undertake the present investigation and to Dr. B. K. Singh, professor of Chemistry, Allahabad University, for his guidance and supervision throughout the present work.

References

1. Dymock, Warden and Hooper - Pharmacographica indica, Vol. 2, p. 555.
2. Kanny Lal Dey – Indigenous Drugs of India, pp. 299-300.
3. Chopra – Indigenous Drugs of India, p. 529.
4. Kirtikar and Basu – Indian Medicinal Plants, 2nd Edn. Vol. 3, p. 1756.
5. Dymock, Warden and Hooper – Pharmacographica Indica, Vol. 2, pp. 556-557.

6. Tauber and Kleiner—J. of Biochem., 1934, 105, 679–82.
7. Brodie—Bull. of Ind. Industrial Research No. 10., Indian vegetable oils p. 34.
8. Twitchell—J. Ind Eng. Chem. 1921, 13, 806-807.
9. Hazura—Lowkowitisch—Chemical Technology and Analysis of oils, fats and waxes 6th Edn, Vol. I, p. 575.
10. Eibner and Muggenthalor—Chem. Tech. of oils etc., 5th Edn., 1, 573.
11. Jamieson and Boughman—J. Amer. Chem. Soc. 1920, 42, 1197.
12. Dymock, Warden and Hooper—Pharmacographica indica, Vol. 2, p. 556.

CYTOLOGICAL STUDIES ON INDIAN PULSES. PART I—THE SOMATIC CHROMOSOMES AND THE PROCHROMOSOMES OF *CAJANUS*

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Communicated by Dr. R K. Saksena.

(Received on January 14, 1940)

SUMMARY

The somatic chromosomes of different species and varieties of *Cajanus* have been investigated. It is found that the diploid number of chromosomes in all the species and varieties is 22. The chromosomes are very small. No morphological differences have been observed in the chromosomes of different varieties. The chromosomes, however, differ among themselves. Some are V-shaped, others J-shaped. Two of the chromosomes bear small satellites.

The chromosomes in some cases exhibit pronounced somatic pairing.

At the resting stage the chromosomes do not form a reticulum but are condensed into chromatic knots, the prochromosomes.

The prochromosomes represent the proximal part of the chromosomes and show an exact numerical correspondence with the diploid number of chromosomes. At prophase the chromosomes become slender and slightly elongated but they never become chromonematic.

Introduction

Very few studies are published about the behaviour of chromosomes in the genus *Cajanus*. They, however, contain very little information save the chromosome numbers. Roy (1933), while studying the development of the female gametophyte in some leguminous crop plants in India, merely records 11 as the haploid number of chromosomes. This number has been verified by Krishnaswami and Rangaswami (1935) in their study of the microsporogenesis of the plant. In view of the economic importance of the plant in India, a detailed cytological investigation is, therefore, undertaken in the hope that such a study would serve as a helpful adjunct to a genetical analysis to be made later. In the following study the behaviour of somatic chromosomes in some varieties of *Cajanus* is described and the problem of prochromosomes is dealt with.

Material and Methods

The material used in connection with this investigation consists of seeds secured from various sources. Pusa types No. 15, 24, 51 and 80 were obtained from Pusa through the courtesy of Dr. Pal, Economic Botanist, Imperial Agricultural Institute, New Delhi, to whom my thanks are due. Of these types it has been

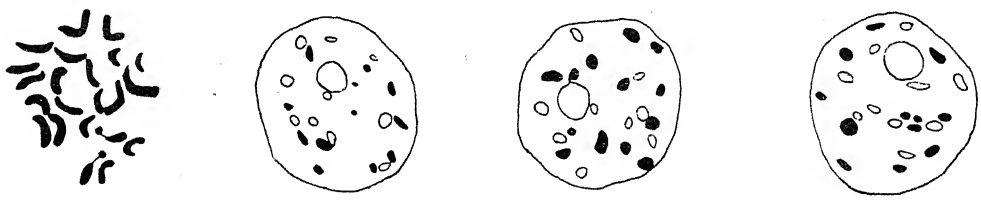
found that Pusa 80 has proved very resistant to the wilt disease caused by *Fusarium vasinfectum* Atk. Type 51 also possesses the quality of wilt resistant and in addition is also high yielding, whereas type 15 and 24 possess high yielding power, but they are non-resistant. Cawnpore variety No. 23 was obtained from the Agricultural Inspector, Allahabad. In addition to these some seeds were obtained from stores in the local market.

The seeds were germinated on wet filter papers in small petri dishes. As roots began to emerge, their tips were cut and were fixed in La-Cour's 2 BE, Medium Flemings and Mæda's modification of Navashin's solution Mæda's fluid gave the best results After fixation the material was run up through the usual schedule, cleared in chloroform and embedded in paraffin. Transverse sections were cut at 10-12 μ in thickness and in all cases stained in Newton's modification of Iodine-Gentian violet.

In order to determine the time best suited to fix the root-tips, the material was fixed during all hours of the day. The most desirable time to fix the root-tips was found to be between 10 P.M. to 12 midnight. An examination of the material of all types indicates that at all other time of the day the root-tip cells are apparently in a resting condition.

Observations

In all the types investigated the diploid number of chromosomes is 22. The chromosomes are very small. No morphological differences were noticed between the chromosomes of the different varieties. The chromosomes, however, differ among themselves, some being slightly curved and others V- and J-shaped. Two of the chromosomes bear small satellites. Fig. 1 illustrates the somatic chromosomes of Pusa 51 type. In this material the chromosomes are generally well spread out, so that their size variation and morphology can be worked out fairly accurately. The chromosomes are rather small, the longest being about 2·7μ and the smallest 1·35μ long. The longest pair is characterised by a median constriction which typically gives it a V-shape. The shortest chromosome pair is also V-shaped. In



1 2 3 4

between these there are medium V's. The arms of the V's are nearly always pointed outward. One pair is well marked, each having a small but distinct satellite, attached by a slender thread to the proximal end of the chromosome. In one pair

the primary constriction is subterminal, giving the chromosome a J-shaped appearance.

Somatic Pairing

At metaphase, pairs of chromosomes are seen to lie close together although they never touch each other. The degree of this somatic pairing is variable. In Fig. 1, it will be seen that nearly all the homologous chromosomes are lying side by side. Every pair can be distinguished clearly by similar shape and size of the chromosomes. This side-by-side position of the chromosomes is apparently due to the residual attraction resulting from homology between the paired chromosomes Somatic pairing was found for the first time by Strasburger in 1905 in plant tissues. Various investigators found this in different plants: Gates (1912) in *Oenothera*, Huskins (1932) in *Mathiola*, Lawrence (1931) in *Dahlia*, Newton (1924) in *Galtonia* and Watkins (1935) in *Yucca*. Watkins has given a detailed list of these plant species in which this phenomenon occurs. Somatic pairing occurs not only in diploids but polyploids also. In *Gossypium* there are indications that four homologous chromosomes are paired together. In the double nuclei formed by the failure of the divided chromosomes to separate at the previous divisions the somatic pairing is well exhibited. The chromosomes in such cases presumably remain together during the resting stage and therefore are in a suitable position to exercise their special attraction on one another during the prophase. Not that somatic pairing is exhibited in plant species only, but it has been found in various animal species also. Metz (1916) has reported somatic pairing in many diploid species of Diptera.

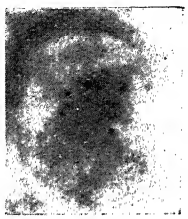
The somatic pairing is more pronounced in those organisms whose chromosomes are small in size and few in number. For in such cases the chromosomes have better chances of free movement which is the requisite condition for the specific attraction between the homologous chromosomes.

Gates (1911) expresses the view that the paired condition between the homologous chromosomes may occur throughout the sporophyte Koller (1934) assumes that somatic pairing may be conditioned by the genotype controlling the degree of attraction between homologous chromosomes.

Prochromosomes

In *Cajanus*, at the resting stage, the chromosomes instead of forming portions of reticulum remain condensed and highly chromatic. A careful count was made of these bodies from several nuclei. In every case it was found that the number of these bodies was 22, showing a precise correspondence between them and the number of chromosomes at metaphase. These chromatic bodies are called 'prochromosomes' by Overton (1905). Grégoire (1907) suggested an alternate name "euchromocentres" which has the advantage of bringing the chromatic bodies of

different kinds into uniform system of nomenclature but the name prochromosome has the widest usage. The appearance of the resting nuclei are shown in Figs. 2, 3 and 4. All these nuclei contain the full diploid number of prochromosomes,



5

6

i e, 2n=22. For purposes of counting, only those nuclei were selected which were uncut and which were not in prophase and telophase stages. Figs. 5 and 6 are photomicrographs of the resting nuclei. Here the condensed nature of the prochromosomes is clearly discernible. It will be seen that none of the nuclei shows the full diploid number of chromosomes. Fig. 5 shows 15 prochromosomes. In Fig. 6 the 3 nuclei show variable number of prochromosomes. In the nucleus at 7 o'clock about 16 of them are visible. This discrepancy is understandable if it is known that in photographs only optical sections of the nuclei can be had. In one focal plane all the prochromosomes do not come. But if the nuclei are examined at different foci, the full diploid number becomes visible.

The Problem of Prochromosomes

The prochromosomes have been the object of cytological investigation for a long time. Rosenberg (1904) while studying the resting nuclei of *Capsella*, *Zostera* and *Calendula*, observed some definite deeply staining bodies which he identified with the pseudo-nucleoles of Rosen (1892) and Zacharias (1895). These bodies were quite distinct from nucleoli and showed a close correspondence in number with the chromosomes. The burning cytological topic of those days was the permanence and individuality of chromosomes and the observation of these chromatic bodies furnished a direct evidence to this problem. Overton (1905) found similar bodies in *Thalictrum* and suggested the term "prochromosomes" for these chromatic granules. Grégoire (1907) named them as "euchromocentres." Laibach (1907) repeated Rosenberg's work on *Capsella* and confirmed his observations on prochromosomes. Since then these prochromosomes have been described by various investigators in large number of plants. In recent years Doutrelinge (1933)

has made a detailed study of the whole mitotic process in a number of plants possessing prochromosomes. By her critical observations she confirms the conclusion reached earlier by Heitz (1929) and Grégoire (1932) that these prochromosomes do not represent the whole of the chromosome but only the proximal region, *i e.*, the spindle attachment parts which become condensed and persist through the telophase. Manton (1935) brought forward conclusive proof from diploid and polyploid individuals and polyploid chimæras of various kinds of *Biscutella lævigata* and *Iberis semperflogens* that the prochromosomes of the meristematic cells correspond in number and position with the chromosomes. She classifies the plant nuclei into two types: the "solid nucleus" which is devoid of free sap and composed entirely of the greatly enlarged bodies of the chromosomes and the "vesicular" or "prochromosomal nucleus" in which the volume of the nucleus is relatively enormous due to the accumulation of the sap outside the relatively small chromosomes

Smith (1934) agrees with Doutrelinge that the prochromosome in somatic nuclei of *Impatiens balsamia* derived directly from the chromosomes by the persistence of the chromatic material on either side and adjacent to the points of spindle fibre attachment but the number of prochromosomes may vary in a nucleus and that it may not contain the full diploid prochromosome number. Further he finds regular presence of fibres at the resting and meristematic nuclei and some of these fibres he regards to represent definite chromonemata. Doutrelinge and Manton of course deny the existence of chromonemata in prochromosomal plants. Smith, therefore, concludes that the behaviour of chromosomes in plants, containing prochromosomes, is fundamentally the same as those in plants with no prochromosomes. Raghavan (1938) has observed prochromosomes in *Polanisia trachysperma* and *Gynandropsis pentapylla* and by following the mitotic cycle in these plants he agrees with Smith in finding that the behaviour of nuclei in prochromosomal plants is essentially like those without prochromosomes. Iyenger (1939), during his study on the cytology of the genus *Cicer*, has found prochromosomes in *C. arietinum* but not in *C. soongaricum*. He also finds the nuclear cycle identical in the prochromosomal and non-prochromosomal plants. Jacob (1940) observes prochromosomes in all species of *Cassia* except *C. auriculata* and also finds a numerical equality between them and the diploid chromosome complements.

Contrary to the mass of evidence in favour of the fact that there is a striking numerical correspondence between the prochromosomes and chromosomes, Lundegärdh (1912) holds that the prochromosomes bear no direct relations to chromosomes. Kuhn (1929) from his studies on *Capparis spinosa* also comes to the conclusion that the prochromosomes are not directly concerned with the formation of prophase chromosomes.

Cajanus affords a suitable material for a critical study of the prochromosomes. In this genus the chromosomes are small and few in number. Both these facts

are indispensible for making an accurate count of small bodies on the surface of a sphere which at the same time contains an opaque nucleolus. In this material conclusive evidence has been obtained in favour of Rosenberg's hypothesis. In a number of nuclei the prochromosomes were carefully counted and in all the prochromosomes were found to be 22 in number. Thus the conclusion seems irresistible that a precise numerical correspodence does exist between the chromatic bodies at the resting nuclei and chromosome numbers.

Further the whole mitotic cycle in *Cajanus* has been carefully followed. It has been found that the prochromosomes do not represent the whole chromosome but only the region containing the spindle attachment constriction. These chromatic bodies maintain their autonomy throughout. At prophase they become slightly elongated and slender but they never lose their identity and never become chromonematic.

Thus the observations on *Cajanus* confirm the results reached by Doutrelinge (1933) and Manton (1935) that the mitotic cycle in the prochromosomal plants is different from that of non-prochromosomal plants.

Explanation of Text Figures

Text figures 1, 2, 3 and 4 were drawn with the aid of Camera lucida at table level, using an achromatic objective N. A. 1·30 Zeiss compensating ocular k×20 and immersed aplanatic condenser N. A. 1·40. Magnification of figures 1–4 ×3000.

Figure 1 shows somatic metaphase, polar view, 2n = 22. Figures 2, 3 and 4 show nuclei with prochromosomes. Figures 5 and 6 are photomicrographs of resting nuclei showing prochromosomes.

References

1. Doutrelinge, J., 1933: *Cellule*, XLII, 31–100.
2. Duthie and Fuller, 1882: Field and Garden Crops, II, 20–34.
3. Gates, R. R., 1911 *Bot. Gaz.*, 51 ; 321–344.
4. „ „ 1912 *Ann. Bot.* 26 : 993–1010.
5. Grégoire, V., 1907 *Ann. Soc. Zool. Malac. Belg.*, XLII, 267.
6. „ „ 1932 *Acad. Roy. Belg. Bull. Cl. Sci.*, XVII, 1438–48.
7. Heitz, E., 1929: *Ber. Deutsche. Bot. Ges.*, XLVII, 274–84.
8. Hooker, J., 1879, Flora of British India, 2, 217.
9. Huskins, C. L. 1932: *Trans. Roy. Soc. Canada* 5 : 1–12.
10. „ „ and Smith, S. G., 1932 : J. Genetics 25 : 241–249.
11. Iyengar, N. K, 1939: *Ann. Bot*, N. S., III, 271–305.
12. Jacob, K. T., 1940: *Ann. Bot.* N. S, IV, 201–226.
13. Koller, P. C., 1934, Genetica, XVI, 447–66.
14. Kuhn, E., 1929: *Ber. Deutsche Bot. Ges.*, 47, 420
15. Krishnaswami, N., and Rangaswami, A. 1935 ; *Current Science*, 3, 614-615.

16. Lawrence, W. T. C., 1931 : *Cytologia*, 2, 352—384.
17. Laibach, F., 1907 : *Bert. Z. Bot.* Centralbl., XXII, 191—210.
18. Lundegärdh, H., 1912: Arch. Zellforsch., IX, 205—330.
19. Manton, I., 1935: *Proc. Roy. Soc.*, B., CXVIII, 522—47.
20. Metz, C. W., 1916: *Journ. Exp. Zool.*, XXI, 213—79.
21. Newton, W. C. F., 1924, *Ann. Bot.*, 38, 197—206.
22. Overton, J. B., 1905: *Jahrb. Wiss. Bot.*, XXII, 274—83.
23. Raghavan, T. S., 1938: *Cytologia*, VIII, 563—78.
24. Robertson, W. R. B., 1930: *Jour. Morphl. Physiol.*, 50, 204—257.
25. Rosen, F. 1892 : Cohn's Beitr. Z. Biol. d. Pflanz., V., 443—95.
26. Rosenberg, O., 1904. Flora, XCIII, 2, 250—59.
27. Roxburgh, 1832, Fl. Ind., III, 325.
28. Roy, B., 1933, *Ind. Jour. Agri. Sci.*, 3, 1098.
29. Smith, F. H., 1934, *Proc. Amer. Phil. Soc.*, LXXIV, 193—214.
30. Strasburger, E., 1905, *Jahrb. Wiss. Bot.* XLII: 1—71.
31. Watkins, G. M., 1935 : *Bull. Torrey. Bot.* Club, 62 : 133—150.
32. Zacharias, E., 1895, Flora, LXXXI, 217—66.

THE USE OF FIELD OBSERVATION IN CLASSIFYING FUNGI IMPERFECTI

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SUMMARY

This paper deals first with the classification of perfect fungi, and shows how, although superficially the groups appear to be based largely on morphological considerations, in fact, examination shows that many genera and species are distinctive ecological, geographical, physiological and genetical groups. Many of the imperfect fungi have been studied and described entirely on artificial media. There are several reasons for this. They are readily cultivated; they are too minute to study in nature; they do not occur pure in nature; many are of industrial importance; finally, they are often quite unsuitable for preservation owing to their fragile nature. Consequently we know insufficient of their incidence and appearance in nature. The view is held that if we could get back to a more thorough study of imperfect fungi on their natural substrata we might get a clearer conception of their classification.

Introduction

The early mycologists were not concerned with plant pathology or with any applied aspects of their science. They were concerned rather with the classification of Fungi on the basis of gross morphology. In this way Linneus, in 1759, classified *Agaricus*, *Boletus*, *Hydnum*, *Phallus*, *Clathrus*, *Elvela*, *Peziza*, *Clavaria*, *Lycoperdon*, and *Mucor*, all large fungi readily recognisable. Persoon, P. A. Micheli, Desmazieres, Schlechtendahl, Link, Fries, Nees von Esenbeck, Corda, Montagne, Saccardo, Cooke, Berkeley, and others made much greater use of the microscope. On the basis of micromorphology they were able to describe many new genera and species, a large number of which continue to be regarded as good species until this day.

The development of plant pathology as a science, starting with the work of de Bary, who proved the pathogenicity of rust and smut fungi and the cause of the late-blight disease of potatoes, gave a marked impetus to the development of systematic mycology, in that it encouraged investigators, too numerous to mention here, to describe and name pathogenic fungi on their hosts.

With the development of the applied aspects of mycology, particularly in America, accompanied by the advance of pure-culture technique, there came a phase when taxonomy pure and simple largely went out of popularity. The control of

plant diseases began to hold sway, and taxonomy appeared to be limited in its scope to the discovery of the large number of fungi causing minor diseases and placing them in their proper groups. Old-fashioned taxonomy appeared in danger of becoming a second-rate science or no science at all, a dry, herbarium study best suited for a hobby for the general botanist. Indeed, taxonomy may well have fallen into such a state permanently were it not for the fact that it is the basis of plant pathology, which can go a certain distance and no further without it. For, throughout biology, systematics should be the classification of organisms based on all the knowledge we have about them Observation of differences promotes classification; classification emphasises further differences; the differences again promote classification. So the cycle goes on indefinitely, the science of taxonomy hand-in-hand with increase in knowledge Without classification, further knowledge cannot be acquired; without further knowledge, there is nothing new to classify. Hence, systematics must aim to include all our knowledge, and a system of classification which does not allow of such inclusion must die, or it will kill science. Hence, also, the impossibility of perfect classification until we are prepared to terminate our efforts to add to knowledge.

The use of ecology in the classification of perfect fungi.—The fungi are divided into three classes on the basis of type of sexuality, namely, Phycomycetes, Ascomycetes, and Basidiomycetes. The "perfect" state, according to the International Rules of Botanical Nomenclature, is "that which ends in the ascus stage in the Ascomycetes, in the basidium in the Basidiomycetes, in the teleutospore or its equivalent in the Uredinales, and in the spore in the Ustilaginales," a very unsatisfactory definition which leaves out entirely the resting spores of the Phycomycetes. There are many fungi with no "perfect" stage, and they are massed together in the so-called "Fungi Imperfecti" or "Deuteromycetes," which are classified on the basis of the type of "inferior" spore produced, its manner of production, shape, septation, and colour. The generic and specific names given to these forms have, according to the International Rules, "only a temporary value," it being assumed as a basis for the rule that they have a theoretical potentiality for the production of a perfect stage. A fair number of the imperfect forms have in fact been linked up with a perfect stage, but the vast majority have not.

Phycomycetes.—The Phycomycetes are divided into three sub-classes. The Zoomycetes are those in which the mycelium is wholly lacking or poorly developed, and sexuality is of a simple sort resulting in fusion of motile gametes. In the Oomycetes copulation is heterogametangic, the female gametangium being larger than the male, and fertilization being accomplished by the passage of one or more male nuclei directly into the oosphere, which rounds up and forms a comparatively thick-walled oospore in the oosphere. The sub-class Zygomycetes shows a third distinctive form of sexuality; there are no oospheres; the male and female gametangia are cells similar in shape and size, true gametangial copulation occurs, and the merged

protoplasts form a thick-walled zygospore, the wall being formed directly from that of the gametangium.

Superficially, it appears as if the Phycomycetes, all the way down through the orders, families, genera and species, are classified simply on the basis of morphology. In fact this is not the case, for ecological relations play a very important part. The Zoomycetes are substantially aquatic or at least moisture-loving organisms, a condition necessitated by the very large and important part played by motile spores in the life-cycle. In the order Chytridiales most of the known species are parasites of plants or animals. Furthermore, most of them are restricted to the geographical zone of Central Europe. All the important species, for example, *Plasmodiophora brassicae*, Wor., the cause of club-root of cabbages, *Spongospora subterranea* (Wallroth) Lagerh. cause of powdery scab of potatoes, *Synchytrium endobioticum* (Schilb.) Percival, cause of wart disease of potatoes, *Olpidium brassicae* (Wor.) Dang., *Physoderma zeae-maydis* Shaw and *Urophlyctis alfalfae* (Lagerh.) Magnus, have all been described in intimate relationship with their hosts. Since the diseases caused by these fungi are of great economic importance and the fungi themselves are not readily mistaken for non-pathogenic forms, we have a fairly good idea both of their distribution in nature and of their relationship to their hosts. Thus they are clearly ecological and geographical species.

Much the same conclusion will be reached if the Oomycetes are considered. The Monoblepharidales, with the single genus Monoblepharis, contains only aquatic species, living usually on decaying twigs lying in water. The Saprolegniales are mostly fresh-water fungi, though *Leptomitus lacteus* (Rath.) Agardh. occurs in drains of paper-mills and sugar factories. *Aphanomyces euteiches* Drechsler and other species of this genus have important parasitic relations and have been carefully studied. One of the three families of the Peronosporales, namely, the Albuginaceae, or "white rusts," contains only obligate parasitic forms, while the parasitic and terrestrial tendencies are highly developed also in the Peronosporaceae, which contains the fungi causing downy mildews of various grasses, grape-vines, lettuce, *etcetera*. An attempt has been made to split the genus *Peronospora* into a very large number of species characterised almost entirely by their parasitic tendencies. Even in the Pythiaceae the description of species is dependent largely on their appearance on the host.

The Zygomycetes are divided into two orders. The Mucorales are typically saprophytic and with a wide distribution on numerous substrates in many countries. The zygospores are typically borne in the aerial mycelium, and the conidia, which are of distinctive forms, may vary from unicellular and deciduous to many-spored in a persistent sporangium. The Mucorales have been studied largely in artificial culture media for which they are eminently suited. In the second order, the Entomophthorales, the Zygospores are typically formed within the host tissues and

the conidia are borne on specialized conidiophores which are adapted to shoot them away at maturity. The Entomophthorales have consequently been studied especially on their insect hosts.

Basidiomycetes.—The Basidiomycetes have, almost without exception, been described on their natural substrates. The sub-class Promycetes contains the Uredinales, or rust-fungi, all obligate parasites, and the Ustilaginales, or smut fungi, all normally parasites though often capable of cultivation on artificial media. When so cultivated, however, the smut fungi are hardly recognisable.

Our knowledge, therefore, of the rust and smut fungi, has been acquired almost entirely from naturally occurring material. We are dealing entirely with what occurs in nature, and not with what might occur, were conditions in nature like those in artificial culture. We have an exact idea of their ecological relationships, and because they are readily observed and important pathogenes, we know in addition a good deal about their geographical location. Furthermore, we have, through genetical research, a very good picture of their breeding behaviour. These genetical studies, have been aided by cultivation on artificial media in smuts, by cultivation on the hosts in the case of rusts. Hybridization of physiologic forms of *Puccinia graminis* Pers., for instance, has been readily demonstrated and new forms, previously unknown, have been produced. It has been shown that *Ustilago avenae* (Pers.) Jens. and *U. levis* (K. and S.) Mag, which cause respectively the loose and covered smuts of oats, readily hybridize, indicating the close relationship of these species. Even intergeneric hybridization has been demonstrated. *Sphacelotheca cruenta* (Kuhn) Potter, which causes loose kernel smut of sorghum, and *Sorosporium reilianum* (Kuhn) McAlp., which causes head smut, having been found to be interfertile.

We can, therefore, fairly conclude that many smut and rust fungi are classifiable into genera, species, sub-species and physiologic forms on morphological, ecological, geographical, genetical and physiological bases. Even among cultivated plants there are few instances where our taxonomy is on a sounder or more useful footing.

The Basidiomycetes proper take a rather different position by virtue of their large size. Many of them are typical saprophytes; the majority are cultivable on artificial media, though admittedly they may then be unrecognisable. Since, however, many can be distinguished with the naked eye by their macroscopic characters, the early orders, families, and even genera became well established and have remained to a great extent unaltered to the present day. Since many are fairly readily identified, we have a fair idea of their geographical distribution, and also of their ecology. We know, for instance, that to a large extent the Agaricaceae are pure saprophytes, that the Thelephoraceae and Polyporaceae contain many timber parasites, and that the Hypochnaceae contain parasites of various herbaceous plants. Various ecological characters have been introduced into descriptions.

A large number of fleshy Basidiomycetes are readily cultivated and have lent themselves to genetical studies which have enlarged our conception of the species. The concept of the species is thus wide in some of the important groups thoroughly investigated, but somewhat narrow in those which are merely unimportant saprophytes, but since, generally speaking, they are based on occurrence in nature, they are certainly " ecological species."

Ascomycetes.—The Ascomycetes form a huge group of fungi, with probably well over 16,000 known species. The Gymnascales are recognised by their character of producing asci naked or grouped together in a loose hyphal pericarp. The largest family, the Saccharomycetaceae have naked asci borne in intercallary fashion or continuously in a short budding mycelium. They are notable for their capacity to ferment sugary solutions, and in spite of their microscopic size a mycologist can guess their presence by the fermented odour produced before actually seeing them, but other families also contain fermenters. Its character of fermenting sugary liquids is thus of group, rather than specific, value and the yeasts are widespread, geographically and in respect of substrate.

The asci, although still exposed, form a definite hymenial layer in the Argyriales, an order containing two families, Argyriaceae and Exoascaceae, which in contrast to the Gymnascaceae contain genera with remarkably highly developed ecological tendencies. There are genera which are typically lichenicole, algicole, fimicole, folicole or lignicole, and these tendencies are correlated with morphological characters. One genus, *Taphrina*, is notable for its tendency to deform the host.

The remaining Ascomycetes fall readily into two major groups, those forming their asci in distinct pericarps, or perithecia, and those forming them in open, cup-like structures, apothecia. A number of the orders form ecological groups. The Laboulbeniales have distinct sex-organs and the perithecia are formed on receptacles. They are as a group parasitic on insects but otherwise are distinguished amongst themselves on morphological bases. In the Perisporiales the perithecia are usually without an osteale. The Eurotiaceae typically have their asci borne on branched hyphae within the perithecium, so that they form no definite arrangement. They are mostly saprophytic, some species being widely distributed in nature on a great variety of substrates. *Micrascus*, however, is typically fimicole and *Thielavia* typically parasitic on the roots of plants. The remaining families in the order have the asci either single or arranged in a basal umbel or a parietal layer. Noteworthy are the Erysiphaceae, which contain only obligate parasites of plants, many of great economic importance and hence well studied. A good deal is known of their relationship to environmental conditions; they can develop at much lower humidities than the downy mildews, and, generally speaking, develop best under temperate conditions. Many, but by no means all, are highly specific pathogenes, so that they are readily determined. The Perisporiaceae contain a small number of parasites.

A large number of fungi in the Capnodiaceae are difficult to distinguish from the Perisporiaceae and the Sphaeriaceae, the chief distinguishing characters being the constricted or dematoid nature of the hyphae, or the formation of slimy scales ; identification is often aided, however, by the distinctive tendency to grow on sticky deposits on the surfaces of leaves attacked by aphids.

The Sphaeriales all have distinctive osteoles, but there the simplicity of identification ends. The number of species is enormous, most are readily cultivable on artificial media, and many appear very different on such media from the naturally occurring fungi. As many of the genera are distinguished by their stromata and by their innate, erumpent, or superficial characters, and as some six hundred genera must be recognised partly on this basis, the impossibility of identifying them from artificial media alone can be appreciated. Furthermore, they are separated somewhat arbitrarily from the Dothideales by the presence of a distinct perithecial wall, which the latter typically lack, though somewhat intermediate forms exist. It is true that the Verrucariaceæ and Mycoporaceæ are parasitic on algae forming lichens, but these are not the groups that matter to the plant pathologist. In practice, the majority of species in the Sphaeriales and Dothideales have been described on their hosts, and on their hosts they shall be recognised. It is also a fact the geographic range of many of the most important parasites is fairly well known and that they are restricted often to certain areas. In some cases these restrictions are due to nothing more than natural barriers, as for example, in the case of *Endothia parasitica* (Murr.) And. and And. which causes the chestnut blight disease, and *Ceratostomella ulmi* (Schwarz) Buisman, cause of Dutch elm disease; in others to climatological factors notably temperature and humidity. The distinction between natural barriers and climatic unsuitability for development is vital in arranging quarantine regulations, and the incorporation of ecological factors in the description of species would seem desirable.

The Phacidiales and the Microthyriales have been described almost entirely in their natural habitats. A number of genera are typically parasitic on higher plants, notably *Schizothyrium*, *Phacidium*, *Rhytisma* and *Lophodermium* while all the *Graphidiaceae* are parasitic on yellow-green algae. The Phacidiales are largely saprophytic or parasitic on algae. The Pezizaceae are mostly saprophytes, typically terrestrial and superficial. The Tuberales are almost entirely saprophytic and hypogean.

Ecological groups in Fungi Imperfecti.—Perhaps one of the greatest mistakes of the systematists has been their determination to relegate to an unimportant position in taxonomy those fungi which produce no sexual stage and, therefore, must be classified on the basis of asexual spores or other structures. Over a thousand genera of such fungi are known, approaching in number the genera of Ascomycetes and greatly exceeding those of Basidiomycetes and Phycomycetes combined. Under all the earlier system the imperfect fungi are classified into orders and families

and the binomial system is applied with generic and specific names. Saccardo's system of classification accepts three orders, the Phomales, Melanconiales and Moniliales, the first-named bearing conidia in pycnidia, the second in more or less cup-shaped acervuli, the third having conidia more er less scattered in the aerial mycelium with no distinctive fruiting body.

Certain species of imperfect fungi have been found, after they were originally described, to be in fact merely stages in the life-history of fungi having perfect stages, *i.e.*, oospores, asci, basidia or promycelia. In accordance with the International Rules of Botanical Nomenclature, the names of imperfect fungi are only of temporary value, and consequently are dropped in favour of the name of the perfect form when that is found. A number of them were found many years ago to be linked with Promycetes. These "form genera" as they are called include *Aecidium*, *Peridermium*, *Caeoma*, *Uredo* and *Roestelia*. All are obligate parasites, and whenever the perfect stage has been found it has proved to belong to the rusts, or Uredinales. Similarly, the form genera *Oidium* and *Oidiopsis* when linked with the perfect stage have always been found to belong to Ascomycetes of the family Erysiphaceae. These, however, are exceptional cases. Too often it is difficult to predict the possible perfect stage merely from the imperfect genus. Species of *Fusarium*, for instance, form perfect stages which fall into four genera, Nectria, *Calonectria*, *Gibberella* and *Hypomyces*. Again, certain perfect genera produce imperfect stages falling into several genera of the Fungi Imperfecti.

The majority of the imperfect fungi have been linked with no perfect stage, and it is doubtful whether they ever will be—certainly not for many years to come.

The majority of Fungi Imperfecti of those groups which have not been linked with the perfect stages of rusts and powdery mildews can be cultivated with some measure of success on synthetic media, either with or without the addition of plant extracts. Their cultivation is of no value from the point of view of studying genetical relationships, since no sexual stages are produced, or if they are produced the fungi are no longer "imperfect." Recently, Hansen and Smith have shown that there may be fusions between hyphae resulting in development of coenocytic mycelium with somewhat different nuclei, which may segregate out again later on, the mycelium with different kinds of nuclei showing a form of growth intermediate between the two different types. There are no nuclear fusions, and unless they occur it is hardly to be regarded as a sexual phenomenon, though it is in a way akin to it. Snyder and Hansen have gone so far as to say that the individual members which go into hyphal fusion in this manner and produce intermediate forms should be regarded as members of one species, and on this basis have merged 41 species, varieties and physiologic forms of *Fusarium* into one single species. It seems, however, premature to do so. Practically all the species they have merged in this way have a high degree of pathogenic specificity, being the chief causes of the most important

wilt diseases of cultivated plants. They have not indicated the pathogenic capacities of such intermediate forms, though they have found that the individual units of the "dual phenomenon" may be recovered and still possess their original pathogenic capabilities. As a basis for genetical relationships between different species and different genera, the usefulness of culture media is naturally restricted to the perfect fungi in which hybridization, interfertility and segregation can be followed as it has been done in the case of smut fungi and higher basidiomycetes.

It is chiefly in Fungi Imperfecti that the morphology of species has been described on culture media, and more especially in the Moniliales. There are several reasons for this. The first is that the members of this order are readily cultured, which of course is essential. The second reason is that individuals of the Moniliales are minute in size. The Phomales produce pycnidia readily seen in nature with the aid of a hand-lens, pure in themselves, remarkable in diversity of shape, size, form of spore, colour of spore masses, manner and degree of submersion of the pycnidia, etc. In addition certain ecological characters are typical of genera; some like *Phyllosticta*, restrict themselves to leaves, other, like *Phoma*, to stems, yet others to roots. Such characters are used extensively in classification. The Melanconiales can also be spotted readily with a hand-lens; the acervuli, as is the case with the pycnidia of the Phomales are in themselves pure and show much diversity of form. In both the Phomales and Melanconiales spores from a single fruiting body or like fruiting bodies occurring adjacently may be assumed to be part of the same fungus, giving sufficient material for a proper statistical account of the fungus. Spores of Moniliales frequently fail to form clear-cut colonies, and it is necessary to separate them from one another by pure-culture methods and study them thus to be certain we are not dealing with several species or even several genera. For the study of such fungi pure-culture methods are essential. Again, the Moniliales contain many fungi which are of industrial importance, such as species of *Aspergillus*, *Penicillium*, *Alternaria*, *Cladosporium*, and *Trichothecium*, of which it has been necessary to obtain sound knowledge of physiology, in consequence of which our knowledge of them in culture far exceeds all we know about them under natural conditions. Finally, the Moniliales are on the whole quite unsuited for preservation in a herbarium, due to their fragile character.

Because most of the Phomales and Melanconiales are plant parasites, we have some idea of their relationship to their hosts and often to their environment. With few exceptions their original descriptions have been made on naturally occurring material. Also, in the case of those causing diseases of cultivated crops, we know something of their distribution. Yet we do not know enough. Altogether too much guess-work is put into the naming of new species. There is a strong temptation when a plant is newly observed to harbour a species of, say, *Phyllosticta*, *Phoma*, *Dothiorella*, *Diplodia*, *Colletotrichum* or *Cylindrosporium*,

to assume that it is a new species before determining whether or not it can pass on to some host already known to harbour a species, on which it might prove to be identical in morphology. However, many of them are fairly specific, and there is some resemblance of actuality, even though further researches may indicate a high degree of synonymy.

In the Moniliales, however, our knowledge of ecology is vague beyond words. Of course, we know that many common moulds are of world-wide distribution, moulds such as species of *Penicillium* and *Aspergillus* and that they occur on numerous substrata. But consider the plant parasites. Several species of *Helminthosporium* cause serious diseases of *Gramineae*. Can we say whether they are normal inhabitants of the soil, whether they grow in the soil or merely survive there, whether they naturally attack and decompose dead plant and animal tissue, at what temperature and humidity they are best able to cope with competition? Species of *Fusarium* are the chief causes of wilt diseases of plants; do they grow in the soil, or do they chiefly restrict themselves to the tissues of their host plants; to what depth can they be found in the soil, and if at much depth are they still active parasites? Indeed, what do they *look like* in nature—in the soil do they form colonies or are they in the form of long isolated strands of mycelium, and if they grow in the soil, do they form spores there? Such questions can be asked about Moniliales throughout, and about a good many Phomales and Melanconiales as well. The reason we know so little about the Moniliales is because we have restricted our studies to growth in culture under conditions to which they are never exposed in nature.

The Relationship between Morphology in Culture and Morphology in Nature.—Fungi in culture differ remarkably from those in nature in morphology and physiology. Morphologically, they differ sharply in two respects: Firstly, they frequently fail to produce certain types of structure entirely. Many Pyrenomycetes fail to produce perithecia. Certain species of *Gibberella*, *Nectria*, *Caloncctria* and *Ophiobolus* can be induced to form them only with the greatest difficulty. The larger Basidiomycetes usually produce no fruiting bodies unless grown in "giant cultures." The sugarcane red-rot-fungus, *Colletotrichum falcatum* Went, instead of forming acervuli, merely produces slimy pionnotal layers with no stroma. *Macrophomina phaseoli* (Maubl.) Ashby, usually fails to form pycnidia in culture, though the sclerotia are produced in abundance. Secondly, in culture fungi often produce certain organs quite different in appearance from the corresponding organs in nature. Species of *Diplodia*, instead of forming separate pycnidia, form them in clusters, sometimes so closely united as to be, for all intents and purposes, dothideoid, chambered pycnidia. The sclerotia of certain fungi become large and fleshy instead of hard and horny as they are on the host plant or in soil. Chlamydospores of *Fusarium* may become three or four times the normal size when the fungi are grown

on liquid media. Smut fungi produce gelatinous masses which do not in the least resemble any structure which they produce on the host plant. Mycelia of many fungi become swollen, thin-walled, or vacualated. Such examples could be multiplied almost indefinitely.

That physiologic changes should occur frequently in culture is natural. Media are usually supplied with abundant nutrients, there is no competition, and the media are often poorly buffered. The result is excessive acidity or alkalinity, accumulation of toxins, with consequent changes in the micro-environment which cannot occur on the living host or in soil. These changes in the micro-environment are probably one cause of the frequent saltations found in certain groups of fungi, among which *Colletotrichum*, *Fusarium*, and *Helminthosporium* are common offenders. As often as not the changes observed in morphology are accompanied by equally great changes in pathogenicity and in other factors.

Discussion

Sufficient has been said, I hope, to show that ecology plays a major part in the description of certain groups of fungi, particularly in those which are essentially or typically parasites. It is also true that the incidence of some important groups is determined by climatic conditions such as humidity, temperature, acidity or alkalinity of the soil, and other minor factors. Quite apart from any question of taxonomy, these facts when fully appreciated are of enormous help to the work-a-day mycologist and plant pathologist for the routine process of identification.

There is no doubt that some of our difficulties and hindrances in both classifying and identifying imperfect fungi are due to the rather suppressive view that the name of an imperfect fungus is of temporary value only. That this rule is useful and necessary is undeniable; but it also cannot be disputed that it loses its usefulness when it leads to the conception of imperfect stages as sub-normal forms derived from sexual stages which can still be produced. There is in reality no reason to suppose that all imperfect fungi have even a theoretical potentiality to produce sexual stages or that they are derived from forms which possessed such stages. They are capable of self-perpetuation indefinitely without the insertion at any time of any form of sexuality; they have an objective existence in time and space and are as truly species as are "species" of bacteria. They have definite relations to their environment, to the media on which they grow, whether it be soil or water or living plant or animal material; they are distinctive in form and shape; many are of enormous economic importance; and they are as deserving of careful classification as any fungi which normally at some time in their life-cycle produce oospores or basidia or asci.

Cultural work has played a considerable part in indicating the genetical relationship between groups of perfect fungi. It plays a greater part in the classification of imperfect fungi for reasons which have been stated. Even when fungi differ enormously in culture from their appearance in nature, cultural work can help in identification so long as the forms produced in culture are regular and distinctive, even if they may be abnormalities which do not occur under natural conditions. Any easy method of recognising his material, however artificial it may seem, is a handy tool for the busy plant pathologist. What we need, however, is more information about the distribution, appearance, and physiology of the fungi as they occur in nature, to be brought into the formal classifications, and it is from field observation that it can be obtained.

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